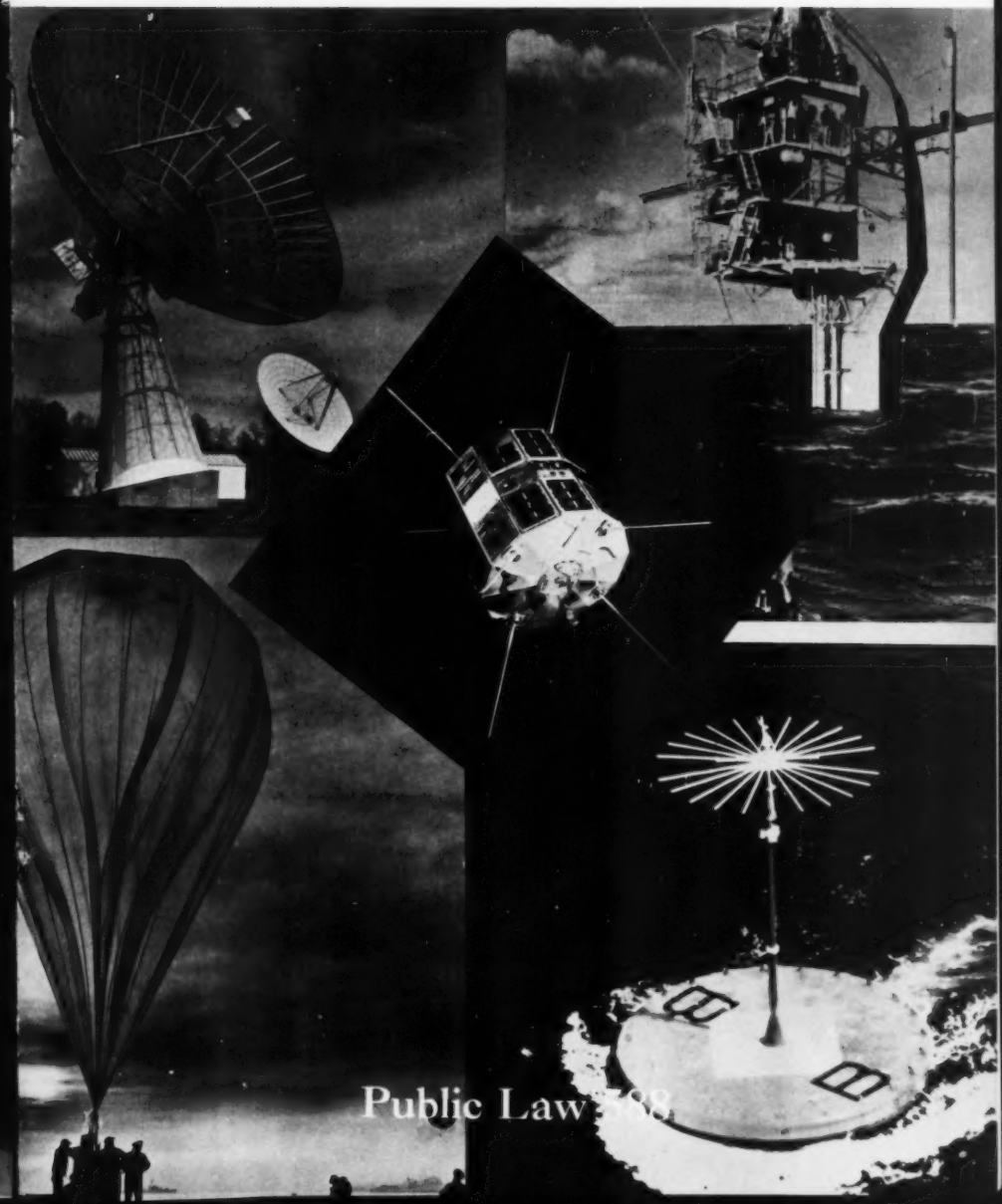
NAVAL RESEARCH

REVIEWS

AUGUST 1971



Public Law 788

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RADM Julius A. Furer and Staff, Coordinator of Research and Development for the Secretary of the Navy, 1943. These were the men whose efforts prepared the way for Public Law 588, which established the Office of Naval Research.
Standing L-R: LT Al Body, LT Bruce Olds, LT Ralph Krause, LT James Parker, LT John Burwell, and LT Mary Wallace.
Seated L-R: LT COL Marion Fawcett, USMC, CAPT Lybrand Smith, RADM Julius A . Furer, CDR Robert Conrad, LCDR Gordon Dyke, LCDR Thomas Wilson.

RADM Furer and Bird Dogs

The evolution of the Office of Naval Research (ONR) is really the story of an educational process carried on over a five-year span. This educational process required the concerted efforts of many people to create an atmosphere in the Navy Department, in the Executive Branch, and in Congress, which was favorable toward long range research.

In 1941 at the request of Secretary Knox, Dr. Hunsaker agreed to serve as the first Coordinator of Research and Development on an interim basis. He selected a small working staff of young men whom he called "bird dogs." After five months Hunsaker resigned the position of Coordinator and turned it over

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ONR After 25 Years

Twenty-five years ago, on 1 August 1946, President Truman signed Public Law 588 establishing the Office of Naval Research. This Act was the culmination of a concept of scientific research and its importance to the Navy and the nation, a concept which was held and vigorously pursued by a small, dedicated group of young naval officers. The founders of ONR went on to earn personal distinction in fields of science and engineering, while the organization they established has become one of the nation's most successful ventures in relating science to Navy requirements and to national purpose and values. The world in which ONR operates today is vastly changed from that of 1946, but in spite of all the intervening scientific, technical, social and international events, the basic purposes for which ONR was established remain valid. The philosophy and language of the enabling Act is as appropriate today as it was in 1946.

During the last few years ONR has faced intense challenges. This is not new. The founders of ONR faced a set of problems which could have strangled the idea. It was necessary to convince the Navy, which had a strong scientific heritage centered in the Navy Bureaus and Laboratories, that it was essential to continue the war-time experiment of supporting university research. The university community was tired of work on war technology and anxious to return to the pursuit of research guided by the inner demands of science. A very significant accomplishment of the early ONR was to assure the country's scientists that it was possible to do research guided by the demands of science and at the same time serve our national purpose through the scientific needs of the Navy. The founders were fortunate in 1946 in having a Congress that was impressed with the scientific war record, eager to see science flourish in the United States, and convinced of the identity of purpose between science and national goals.

After more than twenty years—during which ONR established itself on the forefront of science, developed and perfected the model for Federal participation in university research, and trained a cadre of scientific managers—wide spread scepticism concerning this identity of purpose between science and national policy has manifest itself in serious challenges to ONR on several fronts. The Navy faces decreasing forces and is understandably anxious to provide better hardware now. The university community has strongly questioned the role of government in the support of science, at the same time that the universities are caught up in reassessing their own purpose. Congress, reflecting the changing values and attitudes of society, is highly sensitized to the

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external costs of technology and maybe less receptive to long term benefits.

I believe that ONR is meeting these challenges successfully and meeting them not by cyclic realignment of research projects in reaction to pressures but by thoughtful changes based on the philosophy of the men who started the Office twenty-five years ago. This is a position which believes defense to be an essential and honorable endeavor in support of national goals, which comprehends the strategic role of science and technology in support of national defense, and which believes in the compatibility of selected scientific research, pursued according to the dictates of science, and the scientific needs of the Navy. In meeting the challenges of the last few years based on a faith in the identity of purpose between selected scientific research and the welfare of the future Navy, ONR has emerged with a clearer concept of its role.

New Computer Program Available to Predict Sound Radiation from Submarine-Type Structures

A new computer program has been completed and is being checked by ONR Contractor Dr. M. L. Baron, Paul Weidlinger Consultants, which would allow the reliable and speedy computation of the radiated sound field from submerged ring stiffened shells in the near as well as in the far field. The structural mathematical models of the past were orthotropic shells while the present is a discretely stiffened cylindrical shell with uniform stiffeners which are not identical and not equally spaced. In addition, the ends of the cylindrical shell are closed by hemispherical caps. The program mentioned is best suited to predict far field radiated sound in the important low frequency range.

Computational capabilities of radiated sound predictions hinge on the ability of the structural engineer to predict the in vacuo frequencies and mode shapes of the submersibles under consideration. Preliminary indications suggest the improved accuracy of the discretely stiffened structural mathematical model when comparisons are made with existing experimental data as well as predictions based on orthotropic shell theory. From experimental evidence obtained at the Ordnance Research Laboratory with torpedo-type shell structures, the new program predicts the frequency characteristics of these structures much better than the orthotropic shell theory. The new predictive accuracy for the cases considered is within less than 6 percent error for mode shapes and frequencies, with the majority of the cases correlating within less than 2 percent.

It is anticipated that this computer program will be extremely valuable in the ULMS program preliminary design assessments as well as in silencing efforts for operational vehicles.

Organizational Climates and Performance*

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The problems facing society today—problems of overpopulation, distribution of food, pollution of the air and water, international relations, development and deployment of weapons systems—are of such a magnitude that they can only be solved by the organized efforts of many people. The achievement of NASA in putting men on the moon and bringing them safely back to earth was an incredible feat that required coordinating the work of thousands of individuals, including many scientists, engineers, technicians, and professional managers. It is becoming increasingly important to understand the processes by which work is accomplished through human organizations. How can one best recruit and train the members of an organization, assign them work, create work rules and climates that maximize performance, and adjust the organization's goals and methods to new requirements and technological changes as they occur? These are some of the problems of organizational psychology (1).

A key question has to do with the degree of control over the human components of an organization that should be attempted by the bureaucracy and how that control should be achieved and maintained. The authoritarian manager will be inclined to establish a high level of direct control over the workers by manipulating whatever sanctions he has at his command—salaries, promotions, official reprimands, or the withholding of status symbols such as secretaries and office carpets. The organization member, especially if he has recently been recruited from the halls of academia, will be likely to value his autonomy and resent intrusions on his freedom to deal with problems in his own way. Other managers may seek to establish a more democratic organization in which workers and leaders share in the process of reaching decisions and where responsibility as well as duties are given to workers. Such differences in management philosophy may create different organizational climates—different perceptions on the part of the members of the organization as to the kinds of uniformities in behavior that are thought to be appropriate.

*This investigation was carried out by Educational Testing Service under a contract with the Office of Naval Research and with the cooperation of the California State Personnel Board. The full report is *Organizational Climates and Administrative Performance*, by Norman Frederiksen, Ollie Jensen, and Albert E. Beaton, with a contribution by Bruce Bloxom. The report will be published by Pergamon Press, Elmford, N.Y. under the title "Prediction of Behavior:Interactions of Situational and Personal Variables."

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This report describes an investigation of some effects of organizational climates on the performance of workers in an organization.

The systematic study of organizations has typically involved the observation of performance in existing organizations; experimental methods have rarely been used. But observation of behavior in real life situations is usually unsatisfactory as a method for rigorous scientific work because, first, conditions are not under the control of the scientist, and, second, because the scientist cannot assign subjects to experimental conditions according to a systematic, unbiased plan. Instead, he must accept people who for unknown reasons (such as their own preferences) happen to experience the conditions whose effects are under investigation; bias in assignment of subjects to conditions may be responsible for whatever differences are observed. It is for such reasons that the behavioral scientist prefers whenever possible to take his problems into the laboratory, where he can control conditions and assign subjects to experimental treatments at will.

A rather complex laboratory situation is required, however, if one is to study social organizations. But behavioral scientists are beginning to use experimental settings that simulate complex social situations in a manner that retains much of the realism and complexity of real life (2). The present study represents an attempt to perform a rigorous experiment in such a laboratory setting—rigorous in the sense that subjects were assigned to experimental treatments in an unbiased manner and that all other conditions were carefully controlled. All subjects in the experiment faced identical problems in the same organization, with the same superiors, peers, and subordinates. This was possible because the organization was a simulated one. The problems presented to the subjects may be thought of as constituting a long, realistic situational test in which subjects performed the paper work of an executive in a simulated job (3,4).

The subjects were 260 executives employed by the State of California. Their real jobs ranged from that of department head, appointed by the governor, down to middle-management administrator. They were employed in a wide variety of fields, including health, highways, corrections, forestry, engineering, accounting, and law. The typical subject was a 49-year-old married man, a college graduate, with eight or nine years of experience in administrative work.

The experiment was conducted at a two day "research institute" held at a state college in California. During the two days, each subject served as an executive in the simulated job. He was provided with a desk and was asked to assume that his name was Art Dodd, that he had just accepted a position as Chief of the Field Services Division of the California Department of Commerce (a fictitious department), and that he had come to his office on a Sunday afternoon to get acquainted with his

new job and to get as much paper work done as he could in the absence of a secretary and colleagues to talk to. His instructions were to do whatever he would do if he were actually in the situation. He was to study the materials that had collected in his in-basket and to take whatever action he deemed appropriate, such as writing letters or memoranda, asking for information, calling meetings, making appointments, making notes on his calendar, writing reminders to himself, or throwing things in the waste basket. He was not to play a role, but to be himself. He was not to say what he *would* do; he was to *do* it.

The in-basket items themselves were identical for all subjects. There were letters and memoranda depicting a wide variety of problems, ranging from important questions of policy and personnel to trivial items about the boss's birthday and a litter of puppies. Many of the items were adapted from letters and memoranda taken from the files of real organizations.

The organizational climates were created experimentally. There were two climate dichotomies, arranged in a 2 × 2 experimental design, as shown in Figure 1. One dichotomy involved innovation *versus* rules. Half of the subjects (cells A and B) worked in a climate that encouraged new ideas, originality, and innovation, while the other half (cells C and D) worked in a climate that encouraged following rules, regulations, and standard procedures. The second dichotomy was concerned with

	Global Supervision Climate	Detailed Supervision Climate
Innovation Climate	A	B
Rules Climate	C	D

Figure 1 — The climate combinations

supervision. Half the subjects worked in a climate in which subordinates were given freedom in carrying out assignments (cells A and C); the other half worked in a climate that encouraged a type of supervision in which the details of the work of subordinates were closely monitored (cells B and D).

Each subject first studied documents describing his new job, including such items as organization charts, salary schedules, a copy of the department's annual report, and personnel files. The climate conditions were communicated to each subject by introducing suitable variations in this background information. One kind of variation, for example, had to do with annotations and underlining added to a set of administrative memoranda by Mr. Veep, the Deputy Director. For the rules climate, these annotations called attention to such things as regulations and deadline dates; and for the innovation climate, they called attention to general goals and opportunities for flexibility. There were also memoranda that stated quite directly the preference of Dodd's superior officers for behavior that was consistent with the desired climate. Still other documents were placed in the subjects' in-baskets to keep alive the perception of the climate throughout the experiment. At the end of the experiment, subjects were asked to fill out rating scales to describe the climate of the Department of Commerce. The results showed that the great majority of the subjects had correctly perceived their climate condition.

Subjects also were given tests of various abilities (such as vocabulary, ideational fluency, memory, reasoning, and perceptual speed), inventories intended to measure some major personality variables such as anxiety and sociability, and questionnaires with items of personal history that might be expected to bear some relation to administrative behavior.

At the end of the exercise, each subject left behind in an envelope his written responses to the in-basket items—a large number of letters, memoranda, instructions to his secretary, agenda items, notes on his calendar, and so on. The measures of administrative performance—the dependent variables—are scores based on these protocols.

The method of scoring is based on a list of about 60 categories of behavior, such as *conceptual analysis, postpones decision, takes leading action, takes terminal action, sets a deadline, gives directions to subordinates, follows lead by superior, makes plans only, requires further information, initiates a new structure, takes imaginative courses of action, courtesy to peers,* and *schedules work for a specific day.* There were altogether about 60 items in the in-baskets, an item being a document or a set of documents, such as a letter with previous correspondence attached. The score sheet provides rows, representing in-basket items, and columns, representing categories of behavior. The scorer studies the response to an item and records a *1* or *0* in each cell of the row to

indicate presence or absence of the performance defined by each behavior category. (For some items, such as *number of subordinates involved,* the entry may be a digit other than *0* or *1.*) With these scoring procedures, a 60-item by 60-category matrix is created for each subject. These matrices, one for each subject, constitute the basic data for the analysis. A total score was obtained for each behavior category by considering each in-basket item as providing an opportunity for each of the categories of behavior to occur; the score is the column total—the number of times it did occur.

Such a situational test of course has certain limitations. One is that the subject can make only written responses to the in-basket items. Another limitation is that the test does not permit the subject to respond to the nuances of inflection in speech or to the meaning of the raised eyebrow. But the in-basket test does simulate fairly well an area of administrative work that occupies a large proportion of an executive's time—his paper work. It permits the examinee to display spontaneously those response tendencies that are for him natural or habitual in this work area. Since the subject doesn't know how his responses are to be scored, the behaviors that correspond to the scoring categories are likely to appear to the extent that they are typical of his usual pattern of behavior or are called for by his interpretation of the experimental situation.

The purpose of the study was not only to find out about the main effects of the organizational climates on behavior, but also to investigate the interaction of the two climate dichotomies and the interaction of organizational climates with personal characteristics in influencing performance.

The first step in the statistical analysis was a factor analysis (5) of the performance category scores. The aim was to reduce redundancy in the domain of the dependent variables by identifying the major dimensions of performance and to provide stable measures of these dimensions. Ten performance factors were identified and given the following names:

1. Productivity
2. Acts in compliance with suggestions
3. Interacts with superiors
4. Thoughtful analysis of problems
5. Plans and discusses
6. Defers judgment and action
7. Interacts with peers
8. Orderly work
9. Informality
10. Accepts administrative responsibility

The first factor, *productivity*, is the largest; it reflects the amount of work performed during the work sessions. It was set orthogonal to all the other factors so that none of them is influenced by amount of work accomplished. With the influence of productivity removed, the correlations among the other nine performance factors were quite low. These 10 factors were used as the dependent measures in the analysis.

The major finding with respect to the effects of organizational climates on the means of performance factor scores is that there is a significant interaction of the two climate dichotomies. *Productivity* is significantly different for groups composed of the diagonal pairs of cells in Figure 1. Productivity is increased when climate conditions are compatible (the group composed of cells A and D in Figure 1) and decreased when climate conditions are incompatible (cells B and C). The effect on productivity is most pronounced in the innovation-detailed supervision combination (cell B): the amount of work accomplished as measured by such things as number of actions taken, amount written, number of subordinates involved, and number of items attempted, is appreciably reduced when subjects are asked to work under climate conditions that simultaneously encourage innovation and detailed supervision of subordinates.

The *patterns* of performance are also affected by the climate conditions, as shown by significant differences in the intercorrelations of the performance factors (6). The factor that figures most strongly in these findings is *thoughful analysis of problems*. In both innovation and global-supervision climates, *thoughtful analysis of problems* is negatively correlated with *interacts with superiors* and with *accepts administrative responsibility*, and positively correlated with *interacts with peers*. In rules and detailed supervision climates, the signs of the correlations are reversed. It would appear that the climates that provide more freedom of thought and action to employees (innovation and global supervision) tend to send the more thoughtful subjects out to deal directly with their peers (heads of other divisions, who happen to be the source of many of the in-basket problems). In the more restrictive and controlled climates (rules and detailed supervision) the thoughtful people are, on the other hand, constrained to work through that part of the organization for which they are responsible, and through their superiors—through normal bureaucratic channels.

The question about interactions of climate conditions and personal characteristics has to do with the possibility that organizational climates do not have uniform effects on all individuals, but that people will be differentially influenced, depending upon their individual traits. The answer to the question is provided by comparing the climate groups with respect to the relationships of in-basket performance factors to measures of personal characteristics—the scores on personality, ability, and back-

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ground tests and questionnaires. If the slopes of the regression planes are significantly different, we may assume that the effect of an experimental treatment is not uniform but depends on one or more of these personal characteristics. The results for comparisons in which all predictors were used simultaneously were almost completely negative. The conclusion from these results is that the hypothesis of differential susceptibility to influences of the organizational climates is not supported. Examination of individual correlations between performance factors and predictor measures, however, reveals a number of instances of sizable and individually significant differences in correlations that seem to make theoretical sense.

Another approach to the problem of investigating the influence of situational variables on performance, and the interactions of situational variables with personal characteristics, is to deal separately with various types of in-basket items. The basic data of the study, as we have said, consist of a 60-item by 60-category matrix for each of 260 subjects. This three-mode matrix ($60 \times 60 \times 260$) may be collapsed across people to form an item by performance-category matrix. The intercorrelations of the rows of this matrix show the degree to which the pairs of in-basket items tend to elicit similar behaviors. A principle-components analysis of this intercorrelation matrix provides an empirical method of identifying clusters of items that are similar in the sense that they elicit similar behaviors. Six interpretable item factors were found and given the following names:

1. Items requiring evaluation of procedures for accomplishing organizational goals
2. Items permitting choice of a routine or a nonroutine solution
3. Items requiring solution of interorganizational problems
4. Items requiring solution of personnel problems
5. Items recommending a change in policy
6. Items presenting conflicting demands for staff time

Further analysis, using three-mode factor analysis (7,8) revealed six person-factors. Each person-factor represents a cluster of individuals who are characterized by a certain configuration of relationships between item-factors and performance-factors. One such cluster, for example, consists of subjects who tend to follow rules and employ routine procedures (the *Orderly Work* performance factor) in dealing with in-basket items involving personnel policies and appointments (Item Factor 4 above). The fact that such clusters of individuals exist is indirect evidence of interactions between personal characteristics and situational variables. Not all subjects exhibit the same kinds of responses to particular kinds of items.

When the intercorrelations of person-factor scores are compared for subjects who worked under different organizational climates, striking

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differences are found. This finding shows clearly that the organizational climates influence the interrelationships of the person-factors, which in turn show individual differences in the relationship of performance to specific kinds of problems. Thus we find evidence of a sort of hierarchical interaction: the nature of the interaction between personal and specific situational variables is influenced by broader and more general situational variables—the organizational climates.

To summarize, the experiment shows few direct, simple effects of organizational climates. The major effect of the climates on means of dependent variables was a joint effect of two climate conditions: when climate conditions were not compatible, productivity dropped. The climates individually had important effects on the patterns of performance (the intercorrelations of dependent measures) but not on the means. The three-mode factor analysis shows that individuals differ widely with respect to the way they characteristically respond to particular types of in-basket problems, and that these relationships are markedly influenced by the overall climate of the organization. Thus the interrelationships of climate, personality of worker, and type of task assigned tend to be indirect and complex rather than simple and direct. We are still a long way from understanding the processes of organizations well enough to write prescriptions for their managers. It appears, however, that it is feasible and profitable to study problems of behavior in organizations by using simulated work situations of the sort here described.

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Environmental Factors Controlling the Spread of Oil

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Increasing oil spill incidents in recent years have generated considerable interest among the scientific community in the little-known mechanics of the spread of oil on water. The unpredictability of the timing of this type of incident has provided few situations in which field investigations could be readied in time for detailed *in situ* studies of air-sea-oil interaction. While the Coastal Studies Institute, Louisiana State University, under contract to the Office of Naval Research, is not primarily involved in studies of pollution, it is interested in the dynamics of air-sea interaction and the behavior of currents in the water column. The oil spill provided the opportunity to measure these phenomena on a large scale. In response to requests from the Coast Guard and with approval of the Geography Programs of ONR, the Institute was able to send an experienced team of investigators to the site of the Chevron oil spill in the Gulf of Mexico. The team monitored oil diffusion in response to atmospheric and hydrologic conditions present at the time. Excerpts from the team's finding are summarized here.

When Chevron production platform MP41C, in the Mississippi Delta, caught fire on February 10, 1970, the stage was set for a major spill which would involve as much as 1,000 barrels a day after the fire was extinguished. The well field lay only several miles from the Breton and Delta National Wildlife refuges and about 8 nautical miles from the nearest shore (Figure 1). Two field studies were carried out: one between March 5 and 11 and the other between March 15 and 21. The fire was extinguished during the first field period (on March 10), and the oil spilled freely from the uncapped well during the second period. Three senior investigators, representing specialty areas of wind-driven currents, tidal hydraulics, and march ecology, and two instrumentation engineers participated in the operations.

Data Acquisition

The measurement program aimed at establishing data on the meteorological variables, the tide, current velocities throughout the water column which are wind- or tide-induced, and water density structure of the local water mass (salinity, temperature, turbidity, *etc.*). The oil

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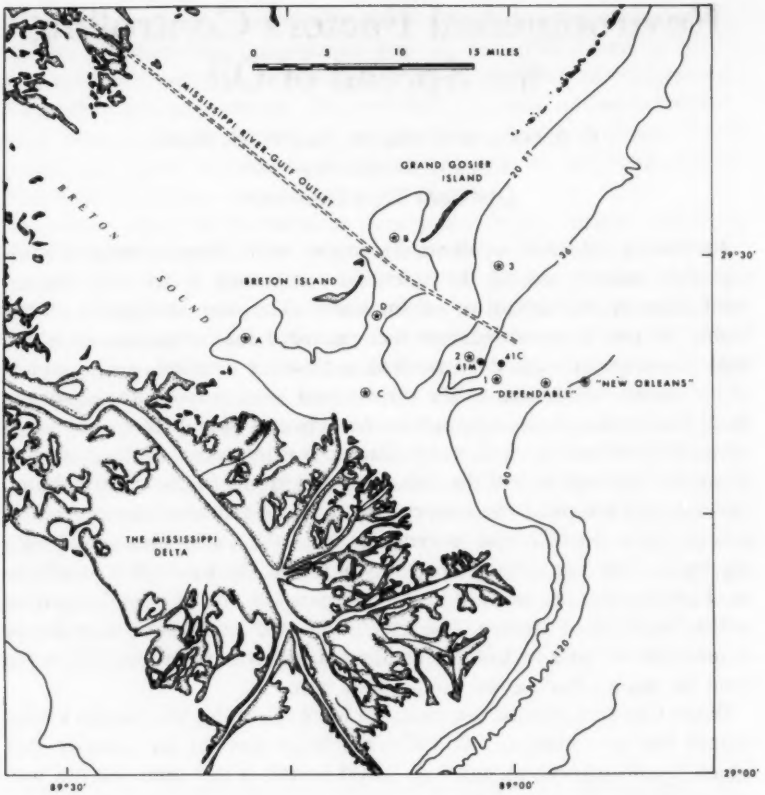

Figure 1 — Location map with stations occupied in study

slick geometry was being determined by routine helicopter reconnaissance by the Coast Guard. The U.S. Geological Survey independently flew aerial photographic missions. Remote Sensing Inc., Houston, Texas, made overflights on which IR thermal imagery was utilized. Data from the above agencies were made available to use for analysis.

The wind speed and direction were read at half-hourly intervals on board the U.S.C.G. cutters *Reliance* and *Dependable*, within about 2 miles of the uncontrolled well, and at hourly intervals on board the lightship *New Orleans*, anchored about 5 miles away.

A Hydro Products model 521 wave-tide gage installed about 1 mile from the flowing well was used to monitor continuously significant wave heights, average wave periods, and tide levels.

Distinguishing wind-driven or tidal currents from the superimposed wave orbital motion near the surface layer presented a considerable technical problem. Roberts and Savonius meters, which are sensitive to wave agitation, could not be used. Most of the useful current data were obtained with a Marine Advisers Q15 ship-borne current meter containing an average circuit to filter out wave orbital motion. Usually, a Beckman RS-5 salinometer was attached to the current sensor to acquire simultaneous readings of salinity and temperature as well as current speed and direction. Two Q15 meters were deployed successively at nine stations surrounding the spilling well (Figure 1) at different times during the study onboard four Coast Guard cutters, *Reliance, Dependable, Pt. Spencer,* and *Pt. Estero.*

Effects of Wind and Wind Drift

Oil from the uncapped well formed a conspicuous plume on the water surface, extending in the downstream direction of the surface current (Figure 2). Some of the oil was sunk by the application of a dispersant, and aerial photographs occasionally revealed a subsurface oil plume, frequently at angles to the surface plume (Figure 2). An aerial (smoke) plume, carrying volatile components of the escaping oil, also showed a different orientation from that of the surface plume. However, a predominant proportion of the escaping oil moved as surface plumes which were sensitively influenced by the wind shear acting directly on the oil surface and by the entraining current.

The surface plume consisted of heavy agglomerated masses of oil, the appearance of which was characterized by "mats" or "rafts." Striations developed along the peripheries of the plume, the orientation of which generally paralleled the wind direction. When winds blew at angles to the plume, striations occurred on both the upwind and the downwind sides of the plume. Thin slicks of oil usually surrounded the plume, and it appeared that the concentration of oil was discontinuous across the plume boundary. Although no attempt was made to measure the thickness of the floating oil, *in situ* observations suggested a thickness on the order of only 1 centimeter.

Figure 3 shows a plot of wind vectors against the slick vectors, which were sighted by helicopter reconnaissance. The broken lines in the slick vector denote thin concentration. The time of slick observation was accurate within only ± 2 hours. In Figure 3, a degree of correlation between the wind direction and the slick direction is recognized. Since the surface current does not necessarily follow the existing wind direction owing to other influences, in particular tides and freshwater outflow from the Mississippi River, a perfect correlation should not be expected.

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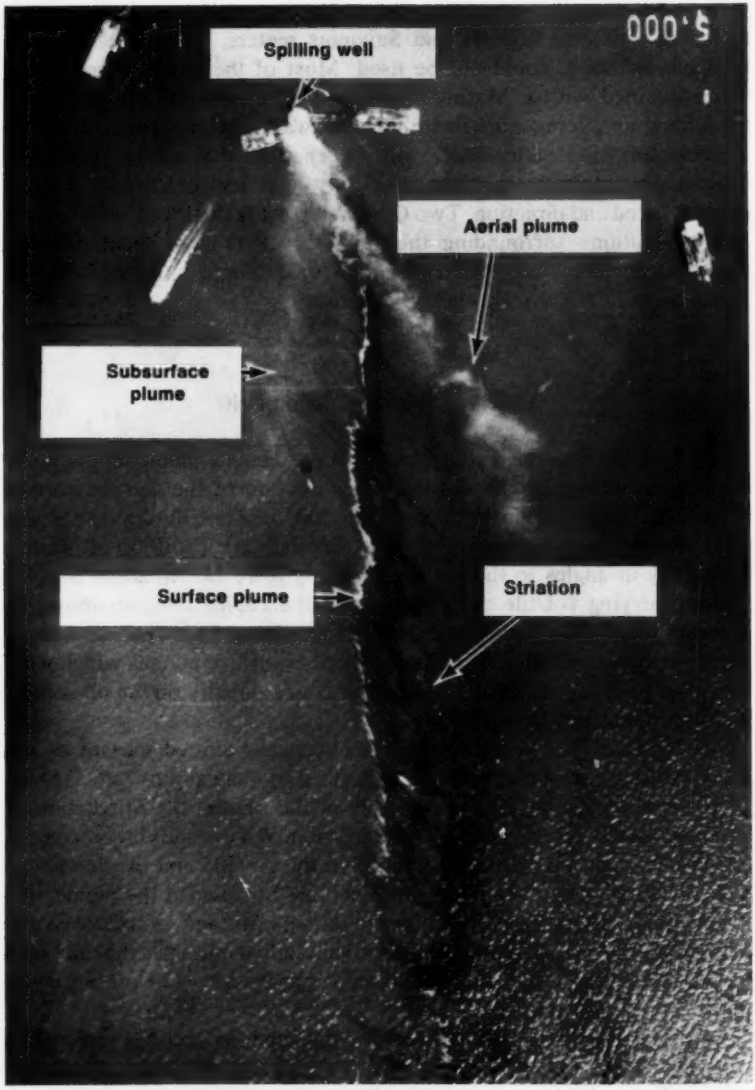

Figure 2 — Aerial, surface, and subsurface plumes moving in different directions from the spilling well. Note striations parallel to the aerial plume, indicating downward elongation. (Photo courtesy of U.S. Geological Survey.)

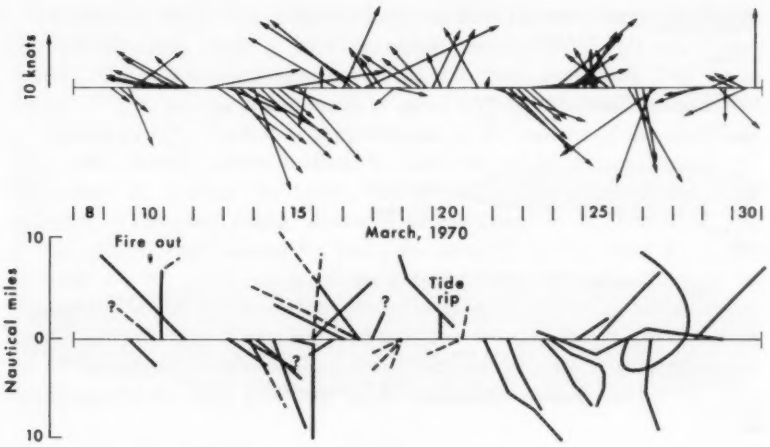

Figure 3 — Wind vectors versus slick vectors

Strong winds should overpower other influences, causing rapid development of surface currents in their direction. Indeed, the correlation between the wind vector and the slick vector was higher during the time of strong winds (*i.e.*, winds over 15 mph) and of steady wind direction. The U.S. Geological Survey photomosaics and color photographs of oil trajectories showed five cases in which oil plumes elongated parallel to the wind (within 20 degrees). Two cases showed no clear indication of wind direction, and one showed a plume oriented at about 90 degrees to the wind direction.

The oil plume leaving the well initially widened rapidly and then gradually became narrower farther downstream. The total length involved seldom exceeded about 15 miles at any given time. These features indicated the important effect of turbulent diffusion acting on the oil layer. On the basis of a few assumptions, the oil plume geometry may be explained by a simple diffusion model. Consider the thinness of the oil layer and hence the negligible effect of plume elongation as a result of vertical shear within the oil film. Assume that there is no slip along the interface between the oil and water and, further, that the longitudinal diffusion is negligible relative to the mean longitudinal displacement caused by the current. Thus, Taylor's one-dimensional diffusion model, in which only lateral diffusion is considered, may be used to estimate the diffusion coefficient from the angle of expansion of the oil plume from the well. Then, a steady state diffusion equation may be solved to obtain the distribution of oil concentration as a function of the diffusion coefficient, the mean current speed, and the discharge of oil at the source. The actual calculation was based on Remote Sensing Inc. IR thermal

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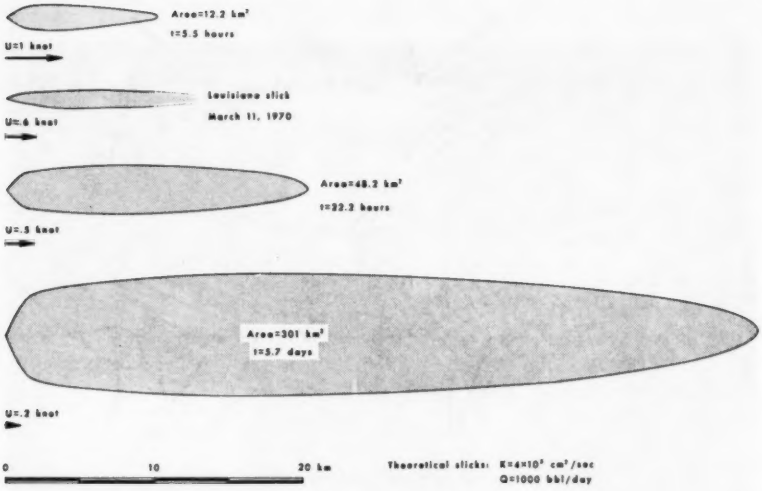

Figure 4 — Comparison of observed slick against theoretical slicks, illustrating effect of decreasing current velocity on slick size

imagery taken on March 11, which led to a diffusion coefficient of 4×10^5 cm²/sec and a concentration along the visible plume boundary of 0.7928×10^{-4} g/cm². Using these values as control parameters and assuming a constant oil discharge of 1,000 barrels/day, as estimated by Chevron, various plume geometries as a function of current speeds were calculated. The result is as follows (see also Figure 4):

$$Y_{max} = \frac{Q}{(2\pi e)^{1/2}\, UC} \tag{1}$$

$$X_{max} = \frac{Q^2}{4\pi KUC^2} \tag{2}$$

$$A \approx \frac{Q^3}{8\sqrt{2\pi e}\, KU^2C^3} \tag{3}$$

in which

Y_{max} = maximum half-width of the slick to the boundary where the concentration is C;
Q = oil discharge at the source;
X_{max} = maximum plume length with the boundary concentration C;
K = diffusion coefficient;
U = mean surface current speed;
A = area of oil plume.

The plume width (Y_{max}) should increase directly with the oil discharge (Q) and decrease directly with the mean current speed (U) (see Equation 1). The width is independent of the diffusion coefficient. The plume length (X_{max}), on the other hand, is more strongly dependent upon the oil discharge (Q), since it is proportional to the square of the discharge (Q^2), and should decrease directly with the mean current speed (U) (Equation 2). Unlike the width, the plume length depends upon the diffusion coefficient, being inversely proportional to it. The total size of the plume, represented by the area covered by the oil (A), would increase as the third power of the oil discharge (Q^3) and decrease as the square of the mean current speed (U^2) and directly as the diffusion coefficient (K) (see Equation 3). Thus, the slender and relatively short oil plume which characterized the Chevron incident appeared to be explained by the high discharge of oil and rather strong surface current.

Effects of Tide

The trajectory of the oil plume extending from the source well was often curved and tended to rotate, indicating the influence of a rotary tidal current. Harmonic analysis of the $Q15$ current records taken within about 2 miles of the spilling well revealed strong tidal components up to as much as 1 knot at 5 feet from the surface. Current ellipses generally were elongated in the north-south direction, and this tended to cause the major excursion of oil to be in the northerly and southerly directions rather than in the easterly and westerly directions.

An example of a typical oil plume trajectory affected by tidal current is shown in Figure 5. Successive trajectories after the initial discharge of oil at t_i are calculated by considering only the diurnal tidal component. Ideally, the plume describes a closed ellipse after a complete diurnal cycle. However, this is precluded by turbulent diffusion, which limits the slick length.

The maximum excursion length of the oil plume from the source can be calculated by combining all the harmonics. Even during the time of tropic tide, when the tidal range is almost 2 feet, the excursion length of the oil plume remained less than about 7 nautical miles from the source. This means that the tidal current alone could not transport the oil to the nearest shore, which was at least 8 nautical miles away.

Effects of Other Factors

The hydrodynamics within the incident area were controlled by various factors such as winds, tides, ocean currents, and density stratification. Moreover, wave action affected mixing in the water layer, which in turn

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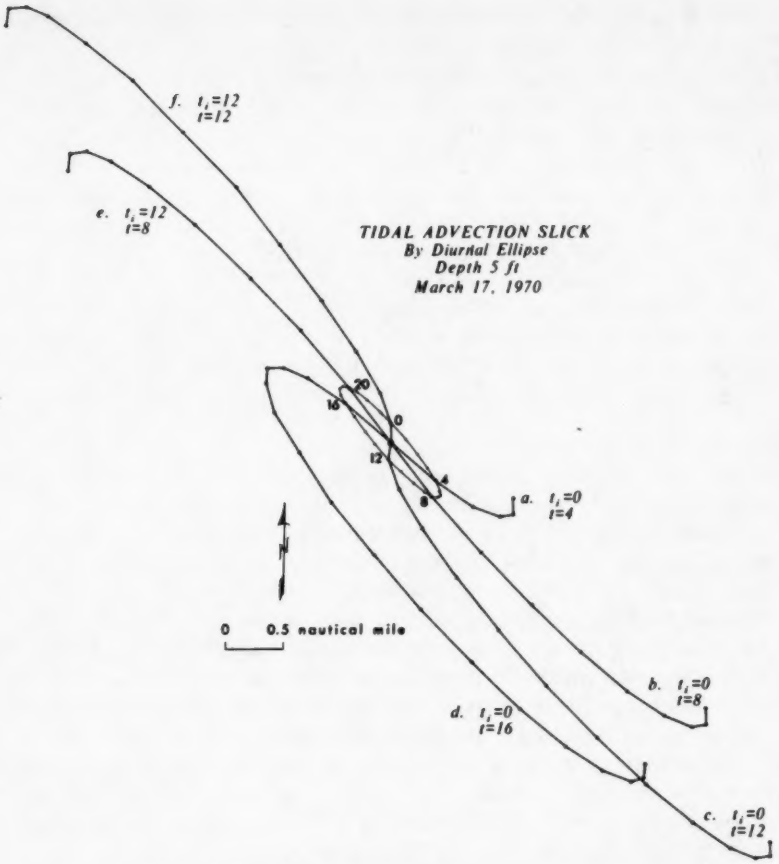

Figure 5 — Traces of oil slick from a continuous source created by diurnal rotary current

influenced vertical eddy viscosity and hence the vertical velocity profile. Field data disclosed indications of the presence of these multiple interactions.

The freshwater discharge from the Mississippi River created intense density stratification. The freshwater layer usually remained on the order of a few feet in thickness, but occasionally a thickness of up to 10 feet was observed. Where the density interface intersected the surface, a "tide rip" was formed, which essentially represented a front of flow convergence. The distributions of the surface freshwater layer and those of density fronts were complex, but they occurred, in general, more frequently in the nearshore zones.

Because of the absence of a velocity component across the front, the oil meeting the rip line tended to spread parallel to it and eventually elongated into a "ropy" distribution, following the configuration of the tide rip. At any given time, a large population of isolated oil patches with ropy features existed in the general neighborhood of the incident area, many of them only up to a hundred feet wide but several miles long.

The oil was usually located on the saline-water side of the tide rip, since saline water generally surrounded the spilling well. This situation served to protect the shores from severe pollution because the oil initially spilling on the saline water was inhibited by tide rips from reaching the shore. An exception to this rule occurred when the oil spilled directly into the fresh water, as happened on March 16. A freshwater layer with sigma-*t* as low as 10 existed at the well location. The oil riding on this layer was swept northward by strong southwesterly winds, landing directly on Breton Island.

The structure of the current in the water column, of which the surface current was only a part, could not be explained entirely by wind and tide alone. It appeared that the incident area, though only as deep as 50 feet, was located at the edge of an oceanic circulation system in the eastern Gulf of Mexico which tended to impose a strong southerly velocity component near the incident well. At one time, the measured influence attributed to this circulation system amounted to as much as 0.8 knot in the entire water column. Because of the complex density structure, the velocity profile was never simple, making it extremely difficult to predict the eventual behavior of the subsurface oil plume.

Concluding Remarks

Although it appears that the wind shear acting on the water surface exerts a dominant control on the movement of oil on water, the present investigation reveals the need of further studies on the fundamental mechanisms involved. Primarily, the shear between the floating oil and the underlying water surface must be established. Field data are needed which include not only the plan view plume geometry but also the thickness of the oil layer. Nothing is known so far regarding loss of oil by physicochemical reaction. Techniques must be developed to monitor the current speed at the thin surface layer of water acted upon by winds. Because of the complex interacting factors which affect the oil movement, an array of multiple sensors capable of remote control and data transmission by a central computer seems to be the only feasible means of handling oil spill incidents. Finally, time-lapse imagery of oil plumes using multiple combinations of remote sensors, including IR thermal imagery, is recommended.

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Acoustic Fatigue of Humans Exposed to Noise

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Human fatigue, or reaction to acoustic stress, is not a very precise phrase and has proven difficult to quantify objectively. One set of environmental conditions that will cause an individual to report (and appear to be in) a state of extreme exhaustion may be a highly motivational condition to another individual. Fatigue is defined as a complex, mutually independent group of deteriorative damage that are ordinarily reversible (*i.e.* overcome by adequate rest and change of activity) but in extreme cases can cause irreversible organic damage or severe mental disturbance (1).

For purposes of organization only, it is possible to borrow terms from the physical sciences and engineering to describe the consequences of overload by noise and serve as reference terms. To those disciplines fatigue is the progressive change of structure and mechanical properties of metals produced by frequently repeated or fluctuating loading. These forces can be described as three progressive stages which: (a) do not result in exceeding the elasticity coefficients (no permanent deformation), (b) bring about material deformation or (c) result in destruction. The stress forces can be mechanical, thermal or acoustic (2).

I shall attempt to discuss something called auditory fatigue resulting from exposure to environmental acoustic stimuli considering both physiological factor changes and psychological modifications, realizing of course that the two functions are really inseparable. Intense acoustic stimulation can impair hearing. The extent of this impairment is related to the duration, intensity and frequency of the stimulation. The threshold of fatigue is definitely lower in terms of intensity than is the threshold of feeling; that is, physiological changes can occur before the psychological awareness of the changes. In other words, people exposed to noise can suffer hearing damage without realizing it (3).

Prior to any discussion of the results of overload, it seems proper to briefly outline the parameters of the various human sensory systems to molecular vibration. These have been broadly categorized into three ranges of frequencies, whose anchors are related to the upper and lower perceptual limits of the young adult's ear (Figure 1). This is the sonic

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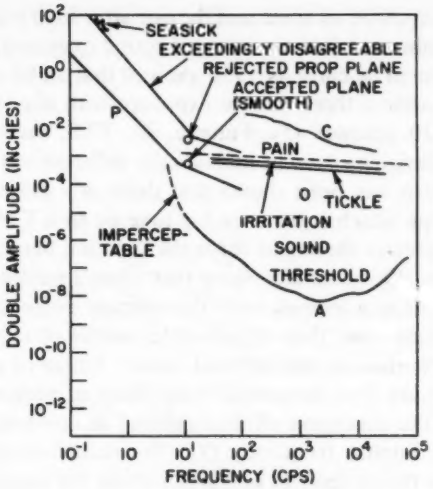

Figure 1 — Outline of the parameters of the various human sensory systems to molecular vibration

range. Frequencies below the sonic range of human hearing (with considerable overlap) are called infrasonics, *i.e.* below 16-20 Hertz (Hz), while frequencies high enough to not be perceived by the human ear are called ultrasonics, around 16 to 20 Kilohertz and above. The sonic perceptual range is an arbitrary one, set by statistical averages of behavioral response to sound. An individual's performance often deviates from the population average. As regards this "statistical ear," then, we can say that (a) it is markedly nonlinear at the intensity levels required for detection of a sound; (b) its most sensitive region, above an arbitrary sound pressure level, is in the frequency region of one octave above and below 1500 Hz (see Figure 1); (c) it is highly resilient even to wide intensity changes; and (d) a sinusoidal signal starts to be perceptually distorted at approximately 120 decibels and becomes intolerably painful at levels around 150-155 dB (4).

Physiological Parameters

Elasticity

Using the terms outlined previously in relation to physical stresses, the elasticity of the auditory system can be described by the human response measure known as the Temporary Threshold Shift, or TTS (5, 6,7). This index is difference, in decibels, between the threshold of

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hearing before exposure to noise and the one after such exposure (usually measured two minutes after cessation of sound exposure, hence TTS_2). Research conducted as early as 1950 showed that an 80 dB tone gives a TTS of 30 dB after a three minute exposure with almost complete recovery in 60-120 seconds (5). Fatigue, *i.e.* TTS, increased with the intensity of the fatiguing tone at individually different varying rates.

More recently it has been shown that there is a growth of TTS_2 for a 4000 Hertz tone which is linear in log time up to a TTS_2 shift of from 40-50 dB. For greater threshold shifts the function becomes linear with time of exposure. This data also show that when a relatively broad-band noise is presented to a listener over the average noise range of 80-130 dB TTS_2 is linear, and that steady-state noises at a particular level cause more TTS_2 than do intermittent noises. Noise of preponderantly low frequencies are less dangerous than those of preponderantly high frequency with the maximum effect exhibited at one-half to one octave above the most intense frequency (7). The data indicate that TTS is probably due to the peripheral portions, *versus* the central portions, of the auditory system since the TTS is not changed by drugs or hypnosis. There seems to be no evidence for biological differences in susceptibility to threshold shifts, although women had a significantly larger TTS_2 for 2000 Hz than did men (8).

A working group was formed by the National Academy of Sciences-National Research Council (NAS/NRC) Committee on Hearing, Bio-Acoustics and BioMechanics (CHABA), to outline "Criteria for Hazardous Noise Exposure." Based upon previous findings, there seemed to be some relationship between the TTS_2 after eight hours of noise exposure and Permanent Threshold Shift (PTS) acquired over ten to twenty years period. Figure 2 gives a summary of the general recommendations concerning intensity–time–octave bands of noise exposure based on the assumption of equivalence of the TTS_2 index to a Noise Induced Permanent Threshold Shift (NIPTS) resulting from long-term noise exposure. Recent data show TTS_2 to be a good predictor for 4000 Hz PTS after ten years. 2000 Hz did not (was less), but was as predicted after 27.5 years (9).

The noise exposure criteria for steady-state noise seems to have enough experimental background to form at least a working hypothesis. The evidence concerning impulse noises is meager. Data about temporary threshold shifts at frequencies from 500 to 13,000 Hz indicate that for fatiguing noises of interpulse intervals of 1, 3 and 9 seconds the TTS was essentially equivalent. Lesser effects were found for noise at 30 second interpulse intervals, but TTS recovery after 5 minutes were almost the same as for the more rapid pulses (10).

The structures of the middle ear, probably the stapedius muscle, aid in preserving the elasticity of the auditory system to continuous noise

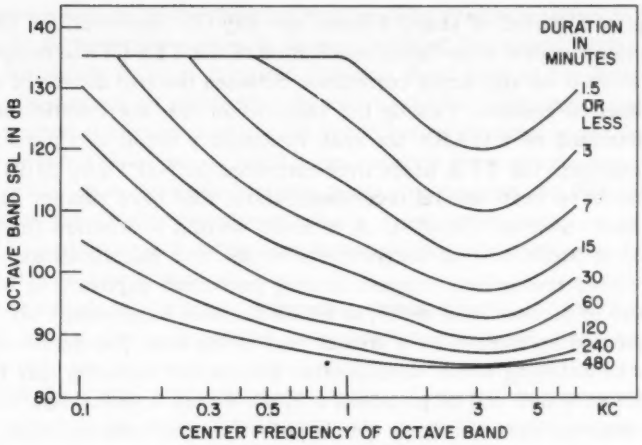

Figure 2 — Each contour describes a set of octave-band levels at which an exposure for the duration indicated will produce average TTSs equal to the damage risk criteria for the various audiometric frequencies

by an activation of the "acoustic reflex" induced by loud clicks or transient narrow-band noise. The TTS was reduced by 11 dB over that expected, by activation of the reflex during exposure to continuous noise (11).

To return to the analogy of structural stresses, the transition between a condition of TTS and PTS can be thought of as a phenomenon where the elasticity range of the ear is exceeded and enters into a state of deformation.

Deformation

"Deafening effects of noise probably started with the discovery of gunpowder, or at least with the industrial revolution, and are only now starting to get out of hand with the invention of the electric guitar" (12).

While it is true that there is a wide range of individual susceptibility differences among a population with regard to the TTS-NIPTS relationship, presently accumulating data seem to indicate that if the time-in-noise criteria are adhered to, 95% of a population will not incur hearing losses (NIPTS) as a result of noise exposure. Permanent losses due to aging processes are confounding, difficult to isolate and are another story. At the present time, we cannot identify the individual susceptible to noise-induced hearing losses, yet noise in excess of 80 dBA are likely to produce some PTS and noises above 105 dBA are almost sure to produce

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PTS after a period of years, 8 hours per day (7). However, we should be cautious against a too broad application of the TTS-PTS assumptions since there is no significant correlation between the two measures using experimental animals. Testing the supposition that the criterion levels recommended by CHABA are real, researchers found in a population of submariners the TTS_2 index over-estimated the NIPTS by 20 dB (13).

There have been several recommendations that have simpler parameters than those of CHABA. A recently revised instruction from the Bureau of Medicine and Surgery sets 90 dB as a hazardous exposure level. Other researchers suggest limiting personnel exposure to 95 dB for noise of narrow band width, or 88 dB for wide band noise (14). With an increased awareness by a greater part of the total population of the effects of polluting noise, several other parameters outlining safe limits to noise exposure will be proposed (15,16). Figure 3 shows how even a slight hearing loss may have significant behavioral consequences and how profound some losses can become (9).

Destruction

Recent evidence from light, electron and scanning electron microscopy has shown damage to the hair cells in the cochlea after exposure to

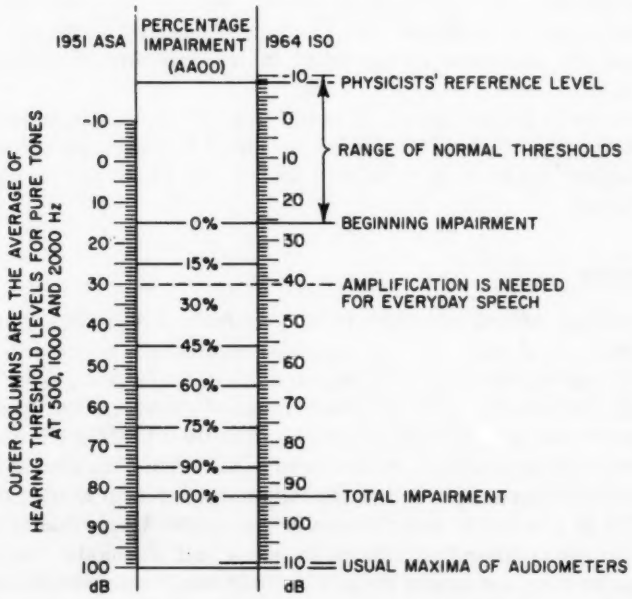

Figure 3 – A slight hearing loss may have significant behavioral consequences

relatively low noise intensity levels (17). The evidence shows that there can be considerable hair cell damage without functional deterioration, yet whenever there is impaired function there always has been found hair cell damage. It seems that damage to the hair cell approximates the place upon the basilar membrane predicted by hearing losses found by audiometry (18). Once a NIPTS has resulted from noise exposure and the individual is removed from the noise environment the PTS does not seem to get functionally progressively worse. Nor does a certain level of PTS make that individual more susceptible to increased noise exposure than it would to a "normal" ear.

In addition to the upper intensity tolerance limits of 150-155 dB for both normal and pathological ears, more recent work concerned only with very low frequency noise concludes that short duration exposure of 150 dB is well within human tolerance limits but that exceeding this level the limiting range of both tolerance and performance was exceeded (19).

Within a population there are individuals who have relatively "tough" ears and others with relatively "tender" ears. At the present time, we do not have sufficiently sensitive or reliable tests to discover the non-average individual at either end of the damage continuum.

Autonomic System Responses

In the previously mentioned study in which upper intensity tolerance limits were explored, certain nonauditory effects were noted, specifically the elicitation of nystagmus. While centroid measures were found, for their population of clinically deaf individuals there was a wide variability of noise levels which produced nystagmus. Generally, lower sound pressure levels for frequencies in the 250-1000 Hz range (125-135 dB) and higher sound pressure levels for the higher frequencies (150-160 dB) were found. A later study to assess nonauditory effects of noise found that sound pressure levels of wide band noise in excess of 120 dB impaired the ability of subjects to perform on the Health Rails, a test of equilibrium. This was especially true if the noise reaching the two ears was not of equal magnitude (20).

Taking a clue from the cardiac response to sudden loud noise, researchers found a decreased pulse amplitude associated with both impulse and continuous noise for all frequencies below 3000 Hz that was monotonic with sound pressure level from 88 to 110 dB. Noise bursts, 90 dB and higher, can induce pupil dilation and vasoconstriction over a 30 minute period with noise bursts of 0.5 second repeated each 1.5 to 3.0 seconds (14).

Various experimenters over the years have used the changes in electroencephalogram (EEG) tracings as indicators of sleep disruption.

Auditory simulation is effective in changing EEG tracings during sleep stages Two and Three but rarely in One (REM) or Four (21). Sound pressure levels as low as 30-40 dB above the awake threshold have been shown to change the EEG patterns in light sleep (*i.e.* stages One, Two or Three), but require 80-90 dB above the same reference to change the EEG during deep (stages Four or One) sleep (22). It is predicted that once the techniques of averaged evoked potentials (AEP) to auditory stimuli have been explored further they will afford perhaps more rigidly objective indexes to the problem of accurate prediction of the effects of noise upon human physiological systems.

Psychological Fatigue

The major portion of the foregoing has indicated some noise effects upon physiological-anatomical factors and that certain of them are reasonably well understood. It is virtually impossible to define psychological fatigue, acoustic or otherwise. One operational definition is that it is the state of an individual that will impel him to seek a change. However, this "definition" would be just as valid for other psychological terms such as drive, motivation or social dissatisfaction.

Elasticity

Probably the closest psychological term to the concept of physical elasticity is that of adaptation. Man seems to become accustomed to meet meaningful stimuli if they are repeated frequently (14). In the normal individual, prolonged auditory stimuli will not be reacted to subjectively, by performance changes, or by EEG pattern changes. Even nonmeaningful noise will be adapted to unless the sound pressure level is too high or the frequency spectrum is of a nature to have unpleasant associations which an individual has learned to associate with that particular sound (23).

Deformation

It could be argued that the interference effects of noise upon communication should not be listed as a deformation phenomenon, but should be classed as belonging for the most part under elasticity, since, except for the extremely high combined signal and noise levels, recovery is affected. However, unless the signal-to-noise (S/N) ratios are changed, the frequency spectra modified or certain temporal relationships are shifted, adaptation, or communication efficiency improvement, does not occur.

It is customary to measure the interference effects upon communication by shifts in intelligibility or by loss of information transfer, whether the latter be ideational or in "bits per second" beyond the seven, plus or

minus two, theorized by Miller (24). The ways by which voice communication efficiency can be improved in various environmental high noise levels has been the subject of considerable research (25). In general, wide band width, low S/N gives higher intelligibility than high S/N restricted band width, since the ear seems to be able to psychologically piece together even fragmentary information from many bands into complete syllables better than more information from fewer bands (12). Figure 4 shows some very interesting interrelationships among various S/N and size of message sets (26).

In addition to the studies reported earlier concerning the pragmatic advantage of utilizing dichotic listening techniques (25), other investigators report that one can expect a 5 dB or more improvement in intelligibility by simply wiring the earphones or loudspeakers 180 degrees out of phase (27).

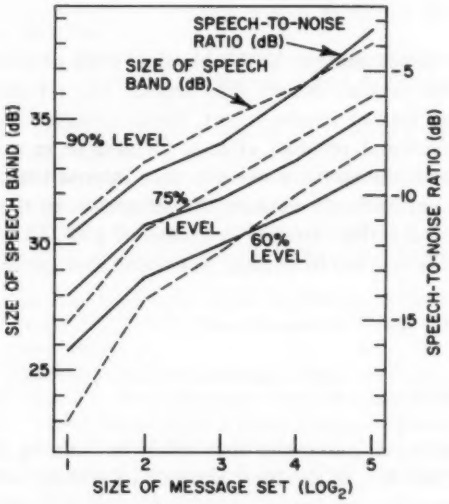

Figure 4 — Relations between the transmission conditions (speech-to-noise ratio as solid-line curves, or speech bandwidth in dB as dotted-line curves) and size of message set in numbers of words, for obtaining given levels of correct transmission, 90%, 75%, or 60%. As the message constraint decreases, that is, as the size of message set increases from 2 words to 32 words, the size of band and/or the speech-to-noise ratio must be increased in order to maintain the desired level of correct transmission (from Pickett, 1961).

Many techniques have been devised to rate the effects of speech interfering noises. The best index of Speech Interference Level (SIL) seems to be one that averages the sound pressure levels of the four octave bands of noise between 300 and 2400 Hz. Using sound level meter (SLM) readings preferred, but all SLM networks overrate noises which contain considerable energy in the high frequency regions (12).

Another topic, whose discussion could occupy much time, concerns the methods and devices employed to protect an individual from high level acoustic exposure. However, as one investigator sums it, "The maximum amount by which an ear protector can reduce the sound reaching the ear is limited to about 35 dB at 250 Hz up to about 60 dB at higher frequencies, *i.e.* greater than 2000 Hz. Of the types of ear protectors, fluid-filled muffs are generally the best, both for attenuation and comfort" (28).

Destruction

There is no direct analogy to the physical state of destruction except those high level impact noises that shatter the tympanic membrane. However, if no further insults occur, these ruptures usually heal with little or no functional residual effects. Of course in a communication situation in which the ambient noise is very intense the combined signal and noise can permanently damage the structures of the inner ear very rapidly. As stated earlier, sounds in excess of 150-155 dB when experienced are usually reacted to as pain; not sound, but general, all pervasive hurt (4).

Absence of Stimuli

One environmental parameter that seems to have an almost universal psychological reaction is the total absence of stimuli, whether acoustic, visual or other sensory inputs. This condition is poorly tolerated by man and other sub-human species. Relative silence is a condition that few individuals have experienced. The usual reactions are extreme apprehension, fear or panic. It is truly an eerie first experience to be in a situation where one can hear one's own heart beat clearly, the vertebrae grate upon each other as one rotates his head from side to side, and where each breath is most apparent, both upon inhalation and exhalation, no matter how one may try to breathe easily. It seems that with but few exceptions, man has adapted to his "noisy" environment so well during his maturation that profound silence is a condition to be avoided.

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First Navy Dual-Hull Research Ship Enters Service

Ocean research takes on a broad, new dimension today with the arrival in Washington, D.C. of the USNS HAYES, the Navy's first catamaran hull research ship.

The HAYES, whose development was sponsored by the Oceanographer of the Navy, is being assigned to service under the technical direction of the Naval Research Laboratory (NRL) for deep sea acoustic and oceanographic research missions. It will be operated for NRL by the Military Sealift Command.

The HAYES will remain in the Washington area for about a month, during which time its laboratories will be outfitted with much of its scientific gear and supplies.

The dual-hull design of the 246-ft long vessel will not only provide a larger, more stable platform for the NRL oceanologists, but will also enable them to lower and raise large or heavy experimental probes through a large center well within the natural protective cavity between the hulls.

The $16-million ship was built by the Todd Shipyard Corporation, Seattle, Washington, and was named after the late Dr. Harvey C. Hayes, a Naval Research Laboratory pioneer in the exploitation of sound for exploring the oceans and detecting underwater objects.

The HAYES is a unique research vessel not only because of its hull configuration and the large ratio of designated scientific space to total ship space, but also because of its propulsion and maneuverability, and a high degree of automation of the ship operations. Its widely separated, controllable-pitch, reversible propellers, powered by twin 2,700 brake horsepower (BHp) main engines, enable the ship to be turned about within its own length.

The HAYES has berthing and messing facilities aboard for 11 officers and 33 crewmen, as well as 30 scientists and engineers conducting research in communications, navigation, position fixing and bathymetry. It displaces 3,180 tons and has a 6,000 mile range at 13.5 knots cruising speed.

On the Naval Research Reserve

Cold Regions Seminar

The Research Reserve Cold Regions Seminar was held at the Naval War College in Newport, Rhode Island, from 19 to 31 July. The seminar was attended by 40 Naval Reservists from all over the country and from several programs outside the Research Reserve. RADM C. O. Holmquist, Chief of Naval Research, opened the seminar with the keynote address, "The Arctic and National Defense."

The subject of the seminar was particularly timely this year. The Arctic has become a vital area in the national defense of the United States. The ability of nuclear submarines to operate or loiter for extended periods in the very noisy marginal ice areas at the edges of the Arctic ice pack presents a major problem in ASW. The growing capability in airborne transpolar deployment of mobile equipment, such as medium range missile sites, can pose a major threat. The recent confirmation of the gas and oil potential of the Alaskan north slope has emphasized the peacetime importance of this frozen area.

The development of the technology needed to meet the problems of −100°F temperature, ice, snow, wind and darkness in winter, and ice, water and low clouds in the summer requires further extensive research. Better knowledge is required of such things as ice dynamics and formation, weather patterns, upper atmosphere magnetics and electronics, and behavior of permafrost to permit design of economic oil recovery and transportation equipment, of surface effect vehicles for transportation, rescue and military needs, of reliable communications for all who venture there.

LCDR Paul Chapman, USNR of NRRC 1-1, the organizing group, structured the seminar program to bring the scientific, technical, military and geopolitical aspects of both the Arctic and Antarctic to the seminar participants. Sixty speakers were selected from the U.S. and Canada, from ONR, the Navy, the Army Cold Regions Research Laboratory at Hanover, N.H., and many commercial companies.

CAPT R. Hill, USNR, ONR Special Assistant for Research Reserve, discussed the future of the Research Reserve. Most attendees were eager to find a contributing role in the Naval Research in peacetime. Suggestions included close ties to "user" scientific offices in ONR which could originate and monitor projects done on ACDUTRA or between two ACDUTRA periods, and restructuring the Research Reserve drill schedule to allow weekend drilling to conduct projects, perhaps at a

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"user" agency to contractor (*i.e.*, Wood's Hole Oceanographic Institution) near the Reserve Company's regular drill site (near NRRC 1-1, 1-2, and 1-7). Weekend drilling would also allow officers from a larger geographical area to be included in one Research Reserve Company by reducing travel frequency (*i.e.*, the New England area). These and other ways of making the large pool of talent in the Research Reserve available to ONR are being explored by NRRC 1-1. Comments are solicited from other Research Reserve Companies and from potential "user" scientists within ONR.

The seminar is the 10th Research Reserve Seminar held in the First Naval District and the fourth organized and run by NRRC 1-1 of Boston.

Research Reservists Review Project on Harbor Design

Members of U.S. Naval Research Reserve Company 11-5 in San Diego recently discussed off shore harbor designs with Mr. Curtis Bernstein, 17, at the U.S. Naval Reserve Training Center in San Diego. Bernstein, an 11th grader at San Dieguito High School in San Diego, received the Navy Cruiser Science Award at the 17th Annual Greater San Diego Science Fair for his work on "Experimentations with Littoral Transport on Various Harbor Designs." His project began as a hobby through which he studied the movement of sand along the California coast. From models in a bath tub he worked his way to Scripps Institute of Oceanography where he received permission to use a large wave simulator to test his harbor design.

Bernstein and his parents, Mr. and Mrs. Richard L. Bernstein of Encinitas, California, were the guests of the research reserve company attending dinner at the Admiral Kidd Club and a lecture by Dr. Robert Lynch, Clinical Psychiatrist, on the subject of a study in the Use of Hallucinogenic Drugs for Clinical Application. With the aid of a home movie Bernstein gave a short briefing of his project prior to the lecture by Dr. Lynch. The meeting was attended by members and guests which included LT Harry Powell, Research Reserve Coordinator from the Pasadena branch office, Office of Naval Research.

The 1st runner up for the Navy Cruiser Science Award in San Diego was Lynn Gordon of Crawford High School. Lynn's project "Kinin Activity in Scorpeana Guttala Venom," involved the study of the venom in the Scorpion fish, a poisonous species found off the California coast. Judging for the Navy award were Dr. Davis Andrews and LCDR Michael D. Carroll of the Navy Undersea Research and Development Center, Dr. Gerald W. Kady, M.D., of the Naval Hospital in San Diego, CAPT Bruce A. Johnson and LCDR Thomas J. De Lacy of U.S. Naval Research Reserve Company 11-5, San Diego.

New Special Assistant for Research Reserve

CAPT C. Hugh Bird, Jr., USN, reported aboard on 12 August 1971 as Special Assistant to the Chief of Naval Research (Research Reserve). His predecessor, CAPT Ross A. Hill, USNR, retired on 1 September 1971. He plans to make his home in the Washington area.

Prior to reporting to ONR, CAPT Bird served in the Communications-Electronics Directorate (J-6), Office of the Joint Chiefs of Staff, The Pentagon, Washington, D.C.

CAPT Bird entered the Navy in 1944 and was commissioned in 1946. Since then, his duty assignments have included command of the USS EXPLOIT (MSO 440) and the USS R. K. HUNTINGTON (DD 781), ASWFORLAND STAFF and Defense/Naval Attache, U.S. Embassy, Kingston, Jamaica.

CAPT Bird has been awarded the following medals: Meritorious Service, Navy Commendation, American Theater, World War II Victory, China Service, Asian and European Occupation and the National Defense Service.

CAPT Bird is a graduate of the George Washington University. He is a native of Portal, Georgia and resides with his family in Alexandria, Virginia.

New Debeaching Technique Tested

Based on a concept developed by LCDR Samuel Gordon of ONR, a technique that could be a significant aid in freeing a ship from a grounded condition has successfully undergone preliminary testing by the Naval Ship Research and Development Center with ONR support at the Naval Amphibious Base, Little Creek, Virginia. The procedure makes use of a mechanical vibration generator whose mounting configuration permits excitation of the hull in the vertical, longitudinal and athwartships direction.

A flat-bottom boat 17 feet in length and with a beam of six feet was used in the tests. In one test, ballast was added to the boat to produce a total load of 3800 pounds. A winch was set up on the beach to debeach the boat in combination with the variation generator or "shaker," which was capable of producing a maximum force output of 1800 pounds S. A. at 60 Hz. The data from the tests indicated that the debeaching force was reduced by 62 percent, 54 percent, and 48 percent respectively, with the shaker exciting the hull in the athwartship, longitudinal and vertical direction. The results of the test show a significant reduction in the force required to debeach a boat with shaker excitation applied to the hull.

More tests are planned to gain a better understanding of the relationship between the vibration characteristics of the hull and the force required for debeaching. It should then be possible to scale these relationships for larger hull configurations, and the results may prove very useful in future ship salvage and amphibious debeaching operations. The Navy is applying for a patent on this debeaching technique.

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Research Notes

Dual Role of NRL's Flying Lab Detachment

Naval Research Laboratory scientists probe the sea, land and air in their quest for answers to physical science questions to ensure advancements in science and technology required by the world's foremost Navy.

Most of the work of the Laboratory is conducted at the main establishment near Washington, D.C., but often scientists must use various field sites that provide unique environment and facilities not available at the Lab.

One such unit is located at Patuxent River Naval Air Test Center, Maryland where Navy scientists go airborne to gather data for scientific investigations as far away as the South Pacific Islands.

These dedicated men and women, who acquire data from instrument-loaded airplanes, agree that their success has been aided immeasurably by the unheralded efforts of the 50 enlisted men and two officers comprising the Naval Research Laboratory's only flight detachment.

Their work for the Naval Research Laboratory has been instrumental in affording NRL scientists a method to conduct a variety of investigations and experiments that would otherwise be an impossible scientific effort.

This highly-skilled, tight-knit group maintains three early models of the Super Constellation, dubbed "Connies," which are flying laboratories used to carry scientists to the four corners of the world.

About half the space in each "Connie" is loaded with scientific instrumentation necessary to conduct a variety of investigations.

There are specially installed equipments, and wing-mounted pods aboard 2 of the "Connies" for cloud physics research, navigation investigations, low-frequency radar study and other projects. Still another "Connie" is used strictly for wave propagation studies in the four-frequency Navy radar system, the only one known in the scientific world.

The NRL Flight Detachment maintains the Navy tradition for providing quick response to immediate needs. For scientific data-gathering, this often represents the difference between success and failure.

Scientists cannot afford extended maintenance periods for unanticipated malfunctions, especially when they occur in the middle of a data-gathering mission. Ideal research conditions which exist today may not reappear for several months or years. In many experiments, the plane operates in conjunction with other Fleet units on a compressed schedule. Because of the limited number of available NRL aircraft and the difficulty involved with installing scientific gear, it is impossible to change planes in the middle of an experiment.

Because of the particular nature of NRL's role in science, the configuration of the aircraft are continually being modified. From the attachment of external pods, probes, antennas *etc.* to an internal rewiring problem or cutting through a pressure bulkhead, the ingenuity of the flight detachment personnel is frequently exercised. Many modifications are not covered in the aircraft manuals and as one crewmember noted, "so many changes have been made, it would be a difficult task to return the aircraft to its original configuration."

Compounding the difficulty is the shortage of men with maintenance experience on the "Connies." But despite this problem, "The high degree of basic professional knowledge possessed by almost all of the men assigned to the unit enables them to quickly assimilate requirements for this type of aircraft," says Lieutenant Dave Hinton, maintenance officer of the unit.

Proof positive that the men, as a unit, possess this basic knowledge can be gleaned from the perfect safety record of the detachment after flying scientists hundreds of hours in search for answers to scientific questions.

"In general, the Flight Detachment bends over backwards to help a project, accommodating themselves and their airplanes within limits of safety and common sense," says Lieutenant Commander Frank Nelson, officer of the detachment. He related that the crews never become directly involved in any scientific experiment; yet their efforts, in addition to maintenance both at the home station and on deployments contribute to the successful results in many experiments. Commander Nelson noted that on a recent flight when a scientist found electrical noise interfering with his measurements, a crew member improved the grounding thus eliminating the problem. He recalled another incident in which a scientific mission in conjection with other Fleet units was threatened by a "Connie" oil line mishap. The crew made the necessary repairs on an airstrip far from the maintenance line and prevented the failure of the scientific mission.

NRL scientists are reportedly impressed with the fact that the crew can respond quickly to almost any emergency on the "Connies" away from home where conditions may be less than ideal for repair. Complete engines have been removed and replaced in this environment.

To prove a point on the distance a scientific mission may take the crew, Commander Nelson related that not long ago they were called upon to fly a mission to Pago Pago, Wake Island and Honolulu. And in the past, he added, trips have been made from the deserts of Africa to the shores of Australia, and from the coasts of Alaska to the mountains of South America.

Other than Commander Nelson, pilots for the "Connies" are Navy Staff Officers from the NRL main location who not only aid the scientists by flying their missions but maintain individual flying proficiency as well.

Home for the NRL Flight Detachment consists of two trailers, a small strip of taxiway, a quonset hut, and office space on the top floor of a building near the southeastern edge of Naval Air Test Center, Patuxent River. The quonset, which contains the maintenance control office, a lounge, and lockers for the flight crews, is a proud possession of the men since they constructed it themselves and maintain it completely.

The Detachment is essentially a self-contained unit in that it has full responsibility for maintenance, quality control and flight support of the NRL "Connies." In addition, it provides its own general support. Unlike many units which have different personnel for ground and flight maintenance, the Flight Detachment personnel perform both functions.

Of the 50 assigned enlisted men, 5 perform general administrative duties. The remaining 45 are broken down into three crews which include flight engineers, a crew chief, mechanics, metalsmiths, electricians, and electronic technicians. Although each crew is assigned to a specific aircraft, limited manpower means that they must be prepared to work on all of them.

The unique "3"—the pilots, crews, and scientists, who fly the Naval Research Laboratory missions, constitute a team. Individually, and as a group, they make vital contributions to man's probe in his advancement of science and technology for the world's most modern Navy.

The Effect of Mercury on Algal Growth Rates

The presence of mercury in fish has raised some interesting questions about the origin of the mercury. This metal is only a trace constituent of the oceans, occurring in concentrations of just 30 billionths of a gram per liter in the deep ocean, but its concentration in swordfish is approximately 20,000 times that. It has been assumed generally that the rather large number of successive steps in the food chain has been responsible for this

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phenomenon, *i.e.* the small plants of the ocean concentrate it in their tissues, and small insects feeding on these plants concentrate it further, and the progression from insects to fish of various sizes results in concentrations in the fish considerably higher than in the water.

The purpose of this study was to determine the effect of mercury, and selected other contaminants, on the growth rates of the algae which constitute the first step in the food chain. If a significant decline in algal growth rates were to result from pollution, there would be drastic consequences in the life in the sea.

It was found that the tolerance of the algae to pollutants depends on the nutritional levels provided: if nutrients are available in abundance, the algae can tolerate considerably higher toxicant concentrations than if the nutrients are limited. Also it was found that in many cases the algae can recover from the effects of certain pollutants provided the nutrients available to the algae are present in sufficient concentrations and enough time is allowed. One of the advantages of the test method devised for this study is that it spans a 3-day period: some of the earlier data on pollution studies were the results of 4-hour tests which do not allow for the recovery aspect of the cells to become evident.

Of the toxicants tested, mercury was the most lethal and there seemed to be no recovery from it if the initial growth inhibition was great. Its toxicity was greater than that of copper, lead, silver, tin, and nickel among the metals, and it was many times more toxic than DDT.

Mercury may be considered somewhat unique in that it was toxic to all species tested, whether freshwater or marine. By contrast, copper is very much more toxic in slightly acid waters than in neutral waters or in the slightly alkaline environment of the ocean. Silver was toxic to two of the marine algae tested (*Chaetoceros galvestinensis* and *Cyclotella nana*) but was relatively harmless to *Phaeodactylum tricornutum*.

The chemical nature of the mercury compound affects its toxicity. In experiments conducted thus far, mercury in the form of mercuric chloride is considerably more toxic than is dimethyl mercury, under the conditions of this test.

This work is being continued, with emphasis on the actual amount of mercury absorbed by algae as a function of the growth conditions used.

(Continued from inside front cover)

to RADM J. A. Furer. Under RADM Furer's guidance the Office of the Coordinator of Research and Development assisted in the planning and establishment of research projects and the utilization of their results by the Navy.

On May 19, 1945 the Office of the Coordinator of Research and Development was taken over by the Office of Research and Inventions (ORI). The reorganization also gave the administration of the Naval Research Laboratory to ORI. Admirals Bowen and de Florey took over from Furer. They won the backing of Under Secretary of the Navy Kenney and Assistant Secretary Hensel. By September of 1945, the "bird dogs" had a Congressional bill drafted for the establishment of an Office of Naval Research.

Aside from Congressional action it was necessary to have the major universities where basic research was conducted accept Navy contracts. CAPT Conrad accompanied by the "bird dogs" visited the universities such as Harvard, Chicago, University of California, California Institute of Technology and Massachusetts Institute of Technology and persuaded them to accept Navy work.

The Vinson Bill establishing the Office of Naval Research passed Congress and become Public Law 588 on August 1, 1946.

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Biodegradation of Oil Pollutants by Yeast and Yeast-Like Fungi

Effort is underway within the Naval Biology Program of the Office of Naval Research to develop new and unique means of ridding the environment of oil and pesticide pollutants. One approach has been to isolate populations of microorganisms which naturally degrade hydrocarbons. These microorganisms are referred to as hydrocarbonoclasts. Research by Dr. D. L. Ahearn, Georgia State University, Atlanta, Georgia, on the hydrocarbonoclastic microorganisms has been expanded to include the yeast and yeast-like organisms.

Dr. Ahearn has examined over 700 yeast isolates from marine and terrestrial habitats. Twenty isolates representing the genera *Candida, Trichosporon, Rhodosporidium,* and several unknown taxa have been selected for their ability to metabolize and/or homogenize crude oil. These yeasts have grown on media prepared with both sea and fresh water. Most strains showed growth on the surface of the hydrocarbon globules; however, several yeasts, mainly marine isolates, have penetrated and developed within the oil globules.

Cover Caption

On the cover are pictures representing some of the early projects sponsored by ONR which are still being continued. Going clockwise from the upper right is: (a) ONR's FLIP (Floating Instrumentation Platform) is photographed "flipped" from horizontal position to vertical from where scientists can conduct experiments on the ocean floor. (b) The "Monster Buoy," which was developed by ONR, is moored at sea to collect, store, and telemeter significant ocean data to shore data stations while unattended for a year. (c) An early weather balloon shown at launching. Today-ONR balloons gather Cosmic ray data at 142,000 feet. (d) The 84-foot radio telescope of the Naval Research Laboratory is used to study radiation of the sun and moon. The telescope has been used for precise position determination of radio sources and study of radio radiation from the planets. (e) In the center is SOLRAD 9 (Solar Radiation Satellite) developed by the Naval Research Laboratory to study solar radiation and solar flares which often disrupt communications.

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